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ABSTRACT

The debate over the nature of effects that new technologies will have on job skill requirements has consequences for public policy and education. Much of the controversy over how to prepare students for the workplace of the future arises because different questions are being addressed. This report examines the disparate visions and disagreements over current realities and trends, including, for example, the assumption that new technologies with heavy reliance on microcomputers will require an increasingly technical work force. These forecast disagreements suggest a lack of harmony with respect to a shared vision rather than flaws in the forecasts themselves. Policymakers must explore ways of altering current trends in order to pursue a course where technologies expand employment possibilities, raise skill requirements, and fully utilize education of the work force. Three types of public policies can assist this task. Increased research on possiblities and their consequences should be encouraged. Second, employers, unions, workers, and government agencies can be informed about these alternative possibilities and consequences. Third, education should assume a more proactive role, responding not only to needs of the work place with such goals as technological literacy but also assuming the power to shape them. Two tables and 41 references are appended. (CJH)

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Abstract

There is widespread controversy over the impact that new technologies will have on the number of jobs and their skill requirements in the U.S. This controversy has important implications for educational policy in preparing the young for the workplace of the future. Much of the difference in views arises because different questions are being addressed. Some commentators raise questions about visions of the future; others address questions of alternative possibilities; still others are concerned about current realities and trends. Although most of the participants in the debate share a common vision, it is often assumed that current trends are inexorably directed towards that vision. We suggest that much of the disagreement with available forecasts of current realities and trends is a response to the lack of harmony of those forecasts with respect to the shared vision rather than major flaws in the forecasts themselves. Yet it is only by having a reasonably accurate picture of where we are headed that we will have the ability to change direction. Accordingly, we suggest other possibilities and how both educational and public policies might alter present paths towards future ones that are more promising.

Introduction

Technology appears to be having a profound impact on jobs in the U.S. Computers, robots, advanced communication systems, and other technologies are creating new jobs, while other jobs are being eliminated as robots and machines take over the work performed by human labor. Even more important, a wide array of existing occupations throughout the economy are being altered as workers begin to use computers, word processors, and other sophisticated devices to perform their jobs.

There is considerable disagreement on the overall impact these technologies will have on jobs and their skill requirements. On the one hand, it is argued that at least some technologies, such as robots, tend to eliminate more jobs than they create, thereby contributing to the high level of unemployment that has existed in the U.S. throughout the 1980s. On the other hand, it is asserted that over the long run jobs will be created at a very rapid rate by the economic expansion generated by new technologies so that any short-run displacement will be more than offset by job growth.

A similar debate has emerged over the effects of new technologies on the skill requirements of jobs. On the one side, it is argued that the new technologies with their heavy reliance on micro-computers will require an increasingly technical work force. There is the assumption that the employment of increasingly sophisticated equipment using micro-computers in factories, offices, and retail stores will require more complex work skills, and particularly those of a technical nature. On the other side, it is asserted that a major effect of the new technologies is to substitute the capabilities of machines for the physical and mental skills of workers, enabling the hiring of less skilled workers at lower cost.

These scenarios have dramatically different consequences for public policy and education. One scenario suggests that the development and application of new technologies will improve substantially the employment prospects of the labor force. According to this view, education and training will require considerable attention to supply the highly skilled and technical workforce required for the future. The other scenario suggests that technological developments may actually undermine employment in the future and further aggravate the high rates of unemployment that have plagued our country since the late 1970s. Consequently, efforts to greatly increase the skills and technical competence of the U.S. workforce must be justified on grounds other than the future labor market.

Why is there such widespread disagreement over the future impact of technology? One reason, of course, is that there is no way to predict the future with absolute certainty. There are many factors that influence jobs and skill levels in addition to technology (Rumberger and Levin 1985), and each of these must be assessed accurately along with its impact on the job market. Some influences such as the probability and impact of war are virtually impossible to predict.

Disagreement also exists, however, because commentators are addressing different questions about the future that tend to yield different answers. The first question relates to visions, the second to possibilities, and the third to current realities. All three questions are related, but they are also separable and independent.

Visions

> What is the desirable role of technology in shaping future jobs and employment?

Each of us has a vision about what we would like to see in the link between technology and jobs. Not surprisingly, there is little disagreement over the answer to this question. Most observers would like to see technology contribute to economic growth, to foster an increase of high-skilled and high-wage jobs, and to eliminate or reduce substantially low-skilled and low-wage jobs. That this vision is widely shared is evident in virtually all discussions on the topic. But, what must be stressed is that this vision is based upon agreement of what should be rather than what is. It is helpful to have concensus on where we should go, but that does not mean that this is the direction that technology is taking us, and we must be careful not to be seduced by the siren of wish-fulfillment.

Current Realities

In order to know where technology is taking us we must ask a different question:

> What are the current realities and existing trends regarding the impact of the new technologies on jobs?

The answer to this question will tell us where we are headed. To the degree that current realities support our visions for the future, there need be little concern. Of course, we should continue to monitor trends to assure that we stay on target in moving towards a desirable future. However, if existing directions are not satisfactory, we might ask a third question.

Possibilities

> What are the possibilities for using the new technologies so that they more nearly fulfill our visions for future jobs and employment?

In order to address a future of improved employment prospects and better jobs, we need to know whether such possibilities exist and under what conditions. One answer to the question is that we live in a world of technological determinism in which the technology itself determines the path of both employment and skill needs of workers. In that event, technology has its own logic and the adoption of new technologies will inexorably translate into a particular path for employment and jobs. Alternatively, technologies may have many general properties which are only translated into employment consequences by applications which are subject to social choice. In that case, it may be possible to use technologies to raise employment and to make jobs more challenging. The major issue is how to create social interventions that alter the present path of technological applications to more nearly address our visions of the future.

In this paper we review these issues in greater detail. The next section provides an analysis of current realities and trends from our own research and that of others. New empirical data are presented to further corroborate the conclusions of this research. In general, it is found that the present trends do not support the popular visions of the impact of the new technologies on the workplace. The following section examines the possibilities of using technologies in a manner that is more suitable for meeting those visions. Specific organizational changes in the workplace are proposed with an analysis of their consequences for productivity and employment. Finally, we explore the policy interventions and educational responses that might provide the shift in technological applications that will move towards our vision of a more productive workplace with full employment and challenging jobs.

Current Realities and Trends

Our previous studies attempted to assess current realities and the likely impact of technology in the future by focussing on three related impacts of technology: on the number of jobs, on the kinds of jobs, and on the skill requirements of jobs. In each case we attempted to summarize existing evidence from a variety of sources to see what the past impact of old technologies had been and what the future impacts were likely to be. The results of this analysis can be summarized briefly.

First we attempted to assess the impact of technology on the number of jobs that would be available in the future (Rumberger 1985). Technology creates jobs as well as eliminates them. Historical evidence does not reveal whether past technologies created more jobs than it eliminated, but it does show that past economic growth created a sufficient number of jobs to compensate for those lost due to displacement. A case study of one new technology--robots-- (Hunt and Hunt 1983) and a recent employment forecast conducted by Wassily Leontief and his colleagues (Leontief and Duchin 1986) suggest that continued technological change will likely displace more jobs than it creates, although future economic growth could continue to provide enough jobs in other industries and occupations to accommodate anticipated growth in the labor force. At the very least, the process is neither smooth nor orderly. A new study by the Office of Technology Assessment of the U.S. Congress found that of 11.5 million workers who lost jobs because of plant shutdowns or relocations from 1979-84, only 60 percent of them had found new jobs during that period (Noble 1986).

Of those who found new jobs, 45 percent had taken pay cuts, and two-thirds were earning less than 80 percent of their former income.

Second, technology also affects the types of jobs available in the economy through its effects on the composition of industries within the economy and on the composition of jobs within industries (Rumberger and Levin 1985). Historical evidence shows that employment growth in the United States during this century first shifted from agriculture to manufacturing and trade, while more recently it has favored service industries. Past technologies tended to reduce the demand for unskilled, physical labor, primarily in agriculture and the goods-producing sectors, while new technologies are displacing mental as well as physical labor in virtually all sectors of the economy. These shifts have expanded employment in professional, technical, managerial, and clerical occupations and reduced employment for laborers and farm occupations. Recent employment forecasts from the U.S. Bureau of Labor Statistics (BLS) suggest that future employment growth will not differ significantly from past changes (U.S. Bureau of Labor Statistics 1985). Although employment in new, high-technology industries and occupations will grow faster than employment generally, few jobs will be created in these areas compared to more traditional service and clerical occupations.

Finally, technology affects the skill requirements of jobs in the economy through compositional shifts among occupations and through changes in skill requirements of existing occupations (Rumberger 1985). In the past, the shifting composition of jobs has tended to favor higher skilled occupations, but a variety of case studies of particular industries and occupations suggest that technologies have generally reduced the skill requirements of particular jobs, ranging from printing occupations to computer programming (Flynn 1985; Spenner 1985). In the future, new technologies will enable robots and other sophisticated machines to perform a greater number and more complex mental as well as physical tasks, while making the operation of these machines easier. Thus skill requirements could be reduced if jobs are not restructured or they could be increased if workers are given more tasks to perform and more decision-making responsibilities (Levin 1984). Case studies indicate that recent technologies have resulted in both impacts, so it remains unclear which tendency will be most likely in the future.

Recently, a number of alternative perspectives about the future have appeared (e.g., Botkin, Dimancescu, and Stata 1984; Honig 1985). Some of these directly challenge the findings in our analyses and criticize the sources of data we use to draw our conclusions, particularly the occupational forecasts of the BLS. In some cases their perspectives are based on new data, such as other case materials, or reanalyses of existing data sources. These alternative perspectives do not merely suggest other possibilities about the future, which we discuss in the next section of the paper, but suggest that the current realities we have described are wrong.

One criticism concerns the accuracy of the BLS forecasts and the validity of their technological assumptions. Our conclusions about the future composition of jobs in the U.S. economy are based heavily, although not exclusively, on recent forecasts of the BLS. The forecasts we examined covered the period from 1982 to 1995, although a forecast that has just been released cores the period from 1984 to 1995. The more recent forecasts continue to support our original conclusions.

We relied primarily on the BLS forecasts not only because they are the most comprehensive and widely known forecasts available, but because the BLS does attempt to account for the effects of technology in forecasting employment changes and because BLS forecasts have generally been quite accurate in predictin general employment trends in the past (Goldstein 1983; U.S. Genera ccounting Office 1985). Some critics claim, however, that future realities annot be inferred from the BLS forecasts because they are not accurate in predicting the employment effects of technologies and, in fact, have no adequate way of accounting for the impact of technology on jobs (e.g., Botkin, Dimancescu, and Stata 1984, pp. 98-104).

As we point out in our previous review of occupational forecasts (Rumberger and Levin 1985), the BLS does attempt to account explicitly for the effects of technology on the number and composition of jobs in the future economy, but not on the skill requirements of existing occupations. Several evaluations of past BLS forecasts have shown them to be reasonably accurate in estimating future occupational employment, especially within large job categories (Carey 1980; Carey and Kasunic 1982). They have also been successful in identifying employment shifts--both employment growth and declines--due to expanded use of new technologies. In general, past forecasts have ter ed to overstate the employment growth and understate employment declines associated with new technologies. For instance, past forecasts overstated employment growth for some engineering occupations and understated declines for telephone operators. Thus, if anything, current BLS forecasts may be _too optimistic_ regarding future employment opportunities associated with new technologies.

But the most important point about the BLS and other employment forecasts (e.g., Leortief and Duchin 1986) is that they provide the only comprehensive and systematic estimates of the impact of technology and other factors on the future job market. They will always have some error and one can always question underlying assumptions used in the models, but on the basis of their past record they are still likely to provide a better indication of how the overall job market will look in the future than generalizing from a few casual observations, guessing, or simple extrapolations of past trends. The point is that none of the latter devices have come close to the accuracy of the BLS forecasts in a world where--by their very nature--no forecast will be perfect.

A different criticism is directed at the fact that our analysis of the BLS forecasts is based on the numbers of jobs that will be available, rather than job openings. We were careful to point out that replacement needs in any period, due to employee turnover, are much higher than new job opportunities, especially in lower-level occupations (Rumberger and Levin 1985, p. 4ΰ3). Replacement needs derive from deaths, quits, and retirements. Some critics have suggested that if we were to focus on total job openings, perhaps we would find a different pattern of resu.ts with a far greater expansion of jobs requiring high levels of education relative to those requiring low levels of education than is evident in studies of new positions (Honig 1985, p. 213).

But, the calculation of future job openings rather than the future composition of jobs only emphasizes our concern about the disproportion of low-level job opportunities relative to higher level ones. Table 1 shows estimates of total job openings for the period from 1982 to 1995 for three of the fastest growing occupations from our original estimates. Computer systems analyst, computer programmer, and electrical engineer have estimated growth growth rates of 65 percent or more between 1982 and 1995. Yet each occupation will generate less than 100,000 new jobs in this 13 year period. Further, these three occupations have very low turnover rates, ranging from 4 to 9 percent per year. Thus the total number of expected job openings from new jobs and replacement jobs in each of these occupations will be between 500,000 and 700,000 over this period.

In contrast, the three traditional occupations--custodians, cashiers, and sales clerks--will grow relatively slowly in comparison with the three technical occupations but will still generate more than 600,000 new jobs over the 1982-1995 period. In addition, these occupations have much higher turnover rates than the three technical occupations, ranging from 22 percent to 33 percent per year, 2 to 8 times the turnover rates for the higher-paying, more desirable technical occupations. Thus the total number of expected job openings from new jobs and replacement jobs in each of these three occupations will be between 10 million and 15 million, from 16 to 32 times the number of openings for the three technical occupations. As these figures clearly show, job openings due to turnover strongly favor the least-desirable occupations in the economy.

One final criticism about the BLS forecasts concerns the occupational categories that are used. It has been suggested that more traditional occupational categories, such as janitors, are defined as a single occupation, while more technical occupations, such as engineers, are subdivided into particular specialties. Consequently, comparisons between individual occupations provide a distorted picture of aggregate trends. Honig points out, for example, that combining all eng neering categories results in a total of more than 400,000 new jobs, putting this group "in the top ten range" of all occupations (1985, p. 213). Yet he ignores the fact that other separate, but related occupations, should also be combined according to this logic. For instance, neither of the two related jobs of fast food workers and kitchen helpers, is included in the "top ten" occupations expected to provide the most new jobs in the future. Yet, combined they are expected to provide more than 600,000 new jobs, which would put the combined category near the top of the list and ahead of the combined engineering categories (Silvestri, Lukasiewicz, and Einstein 1983, Table 1).

It is true, however, that no comparisons between individual occupations can provide a picture of the overall trends in the job market. Will future employment growth favor higher-skilled occupations requiring advanced schooling or lower-skilled occupations that do not?

In order to answer that question, we took information on educational requirements and turnover associated with each occupation in the 1982-95 BLS forecasts and then aggregated the results to see how the educational requirements of jobs in 1982 compare to the educational requirements of new and replacement jobs that were expected to arise between 1982 and 1995. Educational requirements were estimated from 1980 Census data that show the education level of workers within each occupation in 1980. We defined three levels of education: low (high school completion or less), medium (1 to 3 years of college), and high (4 years of college or more). The median amount of schooling among adults is presently equivalent to one year of college and is expected to be higher in 1995.

These estimates reveal the expected changes in educational requirements associated with projected shifts in the composition of jobs, not the educational requirements associated with changes in requisite skills within individual occupations. The educational requirements of future jobs, even within the same occupation, may go up or down because of the impact of technology (Spenner 1985).

Table 2 presents the educational requirements associated with job openings that are expected between 1982 and 1995. The first three columns show the distribution of education for existing jobs in 1982, both overall and within major occupation categories. According to these figures, about two-thirds of all jobs in 1982 required a high school education or less, while the other one-third required 1 to 3 years of college (medium level) or 4 or more years of college (high level). Not surprisingly, educational requirements vary widely among occupation groups: almost 3 out of five professional jobs require 4 or more years of college whereas only 6 percent of service jobs require that much education.

The last three columns show the distribution of educational requirements for the new jobs that are projected for the period from 1982 to 1995. According to these figures, the educational requirements of new jobs over this period will be almost identical to those of existing jobs in 1982. In some areas, such as professional jobs, a smaller proportion of the new jobs will require 4 years of college than existing jobs. If replacement jobs--those arising from turnover--and new jobs are considered together, then the educational requirements of job openings in the future will actually decline, simply because replacement opportunities are expected to be much higher among jobs with low educational requirements.

These findings contrast quite sharply with other estimates of future educational requirements. Honig (1985, pp. 214-215) estimates, using the same BLS forecasts, that 62 percent of all existing jobs in 1982 required what he calls low education levels, a figure that is close to the 64 percent that we estimated. But he then estimates that 46 percent of future job openings (new jobs plus replacement jobs) will require high levels of education compared to 38 percent in 1982. This growth results, in part, because Honig assumes that 40 percent of new clerical jobs will require high levels of education compared to 20 percent in 1982, yet he provides no evidence to support this assumption. In contrast, our estimates show little change between existing and new jobs in any of the occupational groups.

A final challenge concerns the skill requirements of jobs. In our earlier work we concluded that new technologies would not necessarily decrease the skill requirements of existing jobs, but rather that they were unlikely to uniformly raise the skill requirements of jobs. This conclusion was based on descriptions of skill requirements associated with several new technologies, including word processors, cash registers, and computer-aided design equipment, as well as case studies of earlier technologies (Levin and Rumberger 1983; Rumberger 1984). Some recent accounts assert that the increased application of computers and other new technologies will generally require a more skilled work force. Typical of this view is a conclusion reached by Botkin, Dimancescu, and Stata 1984, p. 80):

> A new generation of technology cannot be introduced without a work force skilled at controlling and maintaining sophisticated equipment (p. 80).

While this view implies rising skill requirements in the workplace of the future, it must be viewed as a wishful vision rather than a careful reading of current realities and trends.

Historical evidence has shown that new technologies reduce the skill requirements of some jobs and enhance those of others. One recent review of research on the changing skill requirements of work concludes:

> The rate of change is slow for the labor force taken as a whole. The changes include upgrading and downgrading that approximately offset, leaving aggregate skill levels fairly stable. Compositional shifts appear to account for more of the upgrading trends...content shifts account for relatively more of the downgrading trends. .(Spenner 1985, p. 146).

Another review of almost 200 case studies reaches a similar conclusion: "the skills required by newly created tasks often differ from those of the workers whose jobs are eliminated by the change--hence, while some workers are upgraded, others are downgraded or laid off" (Flynn 1985, p. 37). A review of European studies on changes in skill requirements, including studies of the impact of microelectronics on a number of different industries, found similar results: past technologies have tended to lower the skills of some occupations while increasing the skills of others (Rothwell and Zegveld (1979, pp. 129, 158). The weight of the evidence from studies of individual occupations suggests that the future impact of technology is unlikely to be much different than the past. The skill requirements of some jobs will rise, while the skill requirements of others will decline.

One way that the future may be different than the past is that today's technologies are more pervasive than past technologies so they are likely to affect more jobs and workers. That is already the case with computers, where a recent study found that 30 percent of the workforce is employed in occupations in which at least some workers already use computers (Goldstein and Fraser 1985, p. 1). But the widespread use of computers does not mean widespread changes in skill requirements or education and training. This study found that less than 5 percent of current computer users (less than 1 percent of the workforce) requires long, computer related training (p. 1). The rest primarily use the computer as a tool with standard software packages that require only brief training. As the authors conclude:

> it may seem paradoxical that such widespread use of technology many people associate with abstruse mathematics and electronics can be attained with relatively little special education and training. Yet this conclusion emerges clearly from the many interviews conducted. To understand this, one needs to recall that such innovations as automobiles, television, plastics, telephones, and electricity have become nearly universal while requiring relatively few highly-trained workers, mostly engineers and crafts workers in their manufacture, installation, or repair. The computer is becoming prevalent mainly because it has been designed, and constantly and ingeniously improved, to make it easy to use (Goldstein and Fraser 1985, p. 3).

In our own study of computer use in small businesses, employers report that basic skills and enthusiam are more important in learning to use computers than previous experience and technical training (Levin and Rumberger 1986). A recent study of several European countries also found that only a small fraction of the workforce requires advanced levels of training associated with the use of new information technologies (Jallade 1984).

In summary, the evidence suggests that the new technologies are unlikely to have a profound effect in upgrading the education and skill requirements of jobs, and that most new jobs or job openings will be in occupations that require relatively low skills and education. But, even if this is the current trend, we might wish to ask if other directions are possible and under what conditions they might emerge.

Possibilities

Current realities and trends tell what is happening, but not what is possible. One of the most remarkable characteristics of the new technologies is the wide range of possibilities that they offer in workplace applications. They can be used for the control of production processes or their execution. They can be used to largely automate production and reduce the work force or to serve as powerful tools under the control of existing workers. They can be used to centralize a work process or to decentralize it. And, they can be used to reduce costs of capital, labor, materials, or energy. For example, more powerful and less costly computerized equipment can replace older and less productive equipment; computerized machine processes can reduce both skill and staffing requirements for operators; the high levels of precision and monitoring of such equipment can reduce wastage of materials and increase quality control; and monitoring and optimization of energy usage can result in large energy savings.

The possibilities associated with new technologies not only depend upon the characteristics of the technologies themselves, but also on how they are incorporated into particular forms of work organization. The same technology can have rather different impacts on employment and the skill requirements of workers in different work settings.

Consider the application of micro-electronics technologies. One possibility is for these technologies to be used to further reduce the scope of jobs and make them even simpler and more routinized as the sophistication of the technology displaces worker skills and judgements. The new electronic technologies provide a capacity for centralized monitoring and control of the work process that is unprecedented. Micro-electronic systems for word processing can easily monitor unobtrusively the amount of "active" time of the operator as well as counting keystrokes, entries, words, documents, and pages. These can be used to compare the performance of operators and to rate them and spur competition among them. Such monitoring can be applied to other forms of office work (Andrew 1983) and manufacturing.

Such a restrictive use of technology is predicated on traditional hierarchical forms of work organization with a detailed division of labor and high levels of supervision. This has been justified theoretically by the need to structure the activities of workers in such a way that they can be easily monitored to avoid shirking (Alchian and Demsetz 1972). If a major impact of technological advance is to tighten the monitoring and supervision of workers for a relatively limited set of repetitive tasks, the potential increases in productivity from using technology and education to enhance worker decision-making will be lost (Levin 1984). Highly routinized and restricted forms of work organization do not provide the incentives or scope for worker discretion that will enable and encourage workers to make good decisions in behalf of the firm. These decisions are left to a corps of supervisors and other managers, with corresponding increases in costs and reduced flexibility for the enterprise. The potential of education to improve the ability of workers to allocate resources in production is considered to be one of the most promising ways in which education can contribute to higher productivity (Schultz 1975; Welch 1970), a potential that will not be fortncoming.

A very different possible path is the use of micro-electronic technologies to enhance the decision-making capabilities of workers by decentralizing worker access to information. This application can provide rapid retrieval of data by workers on costs and productive consequences of alternative decisions as well as indicating where there are bottlenecks in production or quality control issues that need attention. Such a use implies a form of work organization in which workers will have the opportunities and incentives to participate in decisions that will improve the productive efficiency of the firm. In this case, the technologies will increase the demands for educated workers. Higher productivity of the firm will expand the industry and employment of workers in the industry, and the resulting competitive gains may also be reflected by gains in international competitiveness of the industry.

To a large extent there exist choices on how the new technologies will be used in the workplace. Two renowned industrial psychologists who have studied the subject have stated:

> Advanced technology presents us with a number of opportunities to develop new, more humane organizational forms and jobs providing a high quality of human life. First, although it poses new problems, highly sophisticated technology possesses an unrecognized flexibility in relation to social systems. There exists an extensive array of configurations of the technology that, within limits, can be designed to suit the social systems desired. Secondly, the new technology both increases the dependence of the organization on the individual and on groups and requires more individual commitment and responsibility in the workplace (Davis and Taylor 1976: 389-90).

The new technologies can be used to make jobs more challenging or less challenging with profound implications for both education and productivity (Shaiken 1985; Walton 1982). In this respect we are not necessarily wedded to a future reality in which the current trends are inexorable. Current trends reflect one path built upon one set of social choices, but they may not be the only ones possible.

The crucial determinant of how technologies will be used and what their impacts will be on both jobs and skill requirements will depend upon the aggregate economy and upon the organization of production. The growth in the aggregate economy and its composition will obviously have an important impact on the number and composition of jobs. This has been widely recognized in the debate over how to promote economic growth generally as well as for particular industries. But, the impact of the organization of firms on jobs, skill requirements, and productivity has been much less discussed. The flexibility of the new technologies is especially broad with respect to their ability to adapt to the organization of the workplace and its labor requirements. For example, microelectronic devices can be integrated into continuous production processes such as assembly lines, or they can be applied to the activities of semi-autonomous work groups whose members rotate jobs, select and train new members, and make group decisions about the way that the work will be performed (Susman 1976).

There is a wide range of evidence suggesting that increased worker participation in decision-making will lead to greater productivity. Such studies are found in automobile manufacture (Coriat 1979; Einhorn and Logue 1982, Gyllenhammar 1977; Logue 1981); in integrated circuits manufacture (Gustavson and Taylor 1982); in a variety of other industries (Kelly 1982) and in studies of a national economy (Faxen 1978). Higher productivity is also reflected in studies of worker cooperatives that are based upon participation and democratic decision-making (Estrin, Jones, and Svejnar 1984) and in the success of the Japanese export industries with their emphasis on worker participation (Ouchi 1981). These studies suggest that there may be greater gains to using technology in participative work situations based upon socio-technical principles of organizational design than in pursuing the more traditional hierarchical model with its routinization of tasks and detailed division of labor (Susman 1976; Thorsrud, Sorensen, and Gustavsen 1976).

But, above all it suggests that there are different possibilities in the use of technology, each with different consequences for the number and composition of jobs and their skill and educational requirements. Although many work organizations appear to use technology presently to cut costs through reducing the size and skill requirements of the work force, that is not the only direction that is possible. The technologies can also be used to provide new challenges to workers in ways that raise productivity of the organization. The overall impact on jobs and skill requirements will depend upon which path is followed in the use of technology. And while the current realities suggest that the move towards participative use of technologies is less prominent than traditional labor-saving uses, there are some significant moves in new directions. For example, General Motors and Toyota have established an automobile assembly plant in California that uses both worker participation and the latest technological equipment. Even more impressive are the plans for GM's project Saturn, a $5 billion investment to produce automobiles on the basis of the new organizational principles (Business Week, 1985). Thus, the projections of existing trends over the short run--for example through 1995--may not be applicable beyond that period when it is possible for major shifts to take place in the organizational use of technologies.

Implications

We began this paper with the assertion that future impacts of technology on jobs and skill requirements can be analyzed from very different perspectives. Some analysts address current realities and trends. Some address the more preferable possibilities, and others indulge in planning for the most optimistic vision of the future. We have suggested that most analysts share a common vision: technology should generate large numbers of challenging jobs that draw upon a strong educational preparation of the population. It is also not clear that there are major differences in assessing the possibilities. Most analysts are willing to acknowledge some flexibility in the way that the technologies are developed and applied.

There is substantial controversy, however, associated with the analysis of current realities and trends because some studies use existing job forecasting techniques to estimate future jobs; others do specific case studies of the applications that they find promising or desirable, and extrapolate those practices to the universe of jobs, even when the cases are relatively unique; and still others look for flaws in any assessment of current realities and trends that do not fit their normative visions of what technology should do in a economically and socially progressive society. We submit that the differences in the conclusions reached about the impacts of technology are largely attributible to differences in these perspectives rather than differences in technique or data among analysts when the same questions are addressed.

Differences also arise because of the time dimension. In our own evaluation of job trends, we have limited ourselves to medium-range forecasts that cover the next decade. Many of the factors that will influence jobs over this period are already in place, so one can make sounder inferences about what is likely over this period. For example, the nature of jobs in 1995 is likely to be heavily influenced by presently available technological applications. Beyond a ten or twelve year horizon, new technological developments can have more profound and unforeseen effects. Moreover, even if radically different organizational principles begin to spread in the economy over the next decade, their impact would not likely be felt before a decade in the overall economy. The reason is that they will require major new investments and reorganization. This will limit the changes initially to particular industries, rather than large sectors of the economy, and there will be a considerable time lag before planned changes are implemented in any widespread way. Accordingly, their overall effects on jobs and skill requirements will tend to be gradual over the near to medium term.

Even in our optimism about new possibilities, we must be sober about the current realities and trends. That is, we should probably not expect any sharp departure from forecasts of existing trends in the absence of war or other cataclysmic events. Our analysis suggests that jobs and their skill requirements in the near future are unlikely to differ much from jobs today: there will be high-skilled jobs and low-skilled jobs just as there are today; even the widespread use of computers and other new technologies is unlikely to increase the skill requirements of most jobs.

But these trends do not have to continue beyond the near future. If we do not like the current trends and want to insure that the distant future more nearly corresponds to the vision most of us share, then we must explore ways of altering current trends in order to pursue a path where technologies expand employment possibilities, raise skill requirements, and more fully utilize the education of the labor force. Given our preference for this alternative path, it is useful to consider what types of public policies might be appropriate to pursue.

Education and Public Policy

There are three ways that the pursuit of deliberate policies could help achieve more desirable outcomes from future technologies. One way is to encourage more research on possibilities and their consequences. We have argued that current technologies are highly malleable with respect to how they are applied in the workplace. In particular, new micro-electronics and nformation technologies can have quite different consequences on jobs and skill requirements depending on how the technologies are used in different workplace organizations. Research could help identify alternative ways of organizing work and utilizing technologies to create jobs, raise skill requirements, and more fully utilize workers' education and training; the costs associated with alternative forms, including recruiting costs and training costs; and the benefits to employers and workers. To some extent these studies would have to be targeted on specific industries, although some similarities across industries could also be identified.

A second role for policy is to inform employers, unions, workers, and government agencies about alternative possibilities and their consequences. In some cases employers may be willing to organize work and apply new technologies in ways that are more beneficial to workers if these alternatives and their consequences are known. For example, using technologies in more participative forms of work organization where workers have more responsibilities and expanded work roles may require more training and hence greater initial costs; but it may also result in longer-term benefits from reduced turnover or higher productivity and greater competitiveness of industries in the international marketplace.

We also believe that more desirable paths will be pursued among available alternatives if those parties that are affected by the technologies are informed of the possibilities and their consequences and take a more active role in choosing their technological destinies. Hence unions should play a role as should other worker organizations, such as professional associations. In the United States, many unions have already become more involved in decisions about work organization and technology use. In some cases this involvement has resulted from unions making concessions on wage issues in exchange for a more active role in worker decision-making. In other cases, employers and unions see mutual benefit in a more cooperative relationship, particularly in the face of increasing foreign competition in their product markets.

A third role for policy concerns education. But we see a very different role than the one that is commonly assumed. Most educators and policymakers view the educational system as playing a reactive role with respect to work. In their view, the educational system must simply react to the future needs of the labor market as these needs become apparent. Current reform efforts are predicated on wishful visions of the future job market. It is simply assumed that most future jobs will require more skills, especially in technical areas such as mathematics and science. So reforms have been implemented to increase the academic requirements for graduation, raise course requirements in science and mathematics, and to improv the quality of schooling and educational achievement.

In contrast, we see a more proactive role for education. In our view, education not only responds to the needs of the workplace, but also has the power to shape them. Consequently, schools and universities should not simply provide the education and training that educators and policymakers think future jobs will require, but should provide the education and training that will help students--as workers, employers, and government officials--to shape the requirements of work. This includes helping to determine how work is organized and technology employed to provide favorable impacts on jobs and skill requirements. It includes the provision of better decision-making skills among workers so that they can use the data provided by an information-rich environment to make better choices regarding the use and allocation of productive resources within the firm.

This latter view of education's role argues for more understanding of technology itself. This "technological literacy" would include understanding how technology shapes our lives, in the workplace as well as outside of it, alternative possibilities, and their consequences. This view also suggests that the best preparation for the future is a general rather than a specific job-focused education, one with a strong foundation in the liberal arts. Many jobs as we know them today will be different in the future. And many workers will change jobs and careers in their lives. The best preparation for a changing work-world is one that stresses flexibility and adaptability. A sound basic education that includes literacy, communication skills, logic and reasoning, mathematics, science, and broad technological applications will enable students to learn new, job-specific skills throughout their working lives as the need arises. It will also enable them to better understand and more fully participate in decisions that affect their lives as workers and citizens.

Finally, it is important to differentiate between visions of the future, possibilities for the future, and current trends and realities. We believe there is a serious danger in ignoring current realities and trends in favor of visions. If we assume that our visions will be fulfilled--regardless of the directions of current trends and realities--we may become complacent about the future. No policy action will be taken, when such action is clearly warranted to pursue the possibilities which will fulfill our visions. We must pursue the potentially beneficial impacts of technology, rather than simply sitting back and waiting for our visions to be fulfilled.

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TABLE 1

Job Openings for Selected Occupations, 1982-1995

Occupations	Existing Jobs 1982 (thousands)	Annual Replacement Rate (percent)	Job Openings, 1982-85		
			New Jobs (thousands)	Replacement Jobs (thousands)	Total (thousands)
Computer system analysts	254	5	217	236	490
Computer programmers	266	9	205	431	636
Electrical engineers	320	4	208	220	540
Building custodians	2,828	22	779	9,202	9,981
Cashiers	1,570	33	744	8,331	9,075
Sales Clerks	2,916	31	685	13,132	13,817
Ratios					
Custodians/Programmers		2.4	3.8	---	15.7
Sales clerks/Electrical Engineers		7.8	3.3	---	25.6

NOTE: New jobs were derived from the moderate trend forecast from the BLS. Replacement jobs were estimated by applying the annual replacement rate to the average projected employment level for the 1982-95 period.

SOURCES: George T. Silvestri, John M. Lukasiewicz, and Marcus E. Einstiein, "Occupational Employment Projections through 1995." Monthly Labor Review Vol. 108 (November 1983), pp. 37-49; Alan Eck, "New Occupational Separation Data Improve Estimates of Job Replacement Needs," Monthly Labor Review, Vol. 107 (March 1984), pp. 3-10.

TABLE 2

The Educational Requirements of Jobs, 1982-95

(percentage distribution)

Occupation Group	Existing Jobs, 1982			New Jobs, 1982-95		
	Low	Medium	High	Low	Medium	High
Professional/technical	18	23	59	20	28	52
Managerial	41	26	33	40	26	34
Sales	51	20	29	49	21	30
Clerical	67	25	8	67	25	8
Craft	78	17	5	78	17	5
Operatives	89	9	2	89	9	2
Service	75	19	6	75	20	5
Laborers, except farm	83	14	3	84	14	2
Farm workers	82	11	7	84	10	6
All jobs	64	19	17	60	22	18
All job openings (new jobs plus replacement jobs)				69	19	12

NOTE: Educational requirements represent the years of schooling completed by job incumbents as reported in the 1980 dicennial Census. They are divided into three categories: low (0-12 years of schooling), medium (1-3 years of college), and high (4 or more years of college). Educational distributions were calculated for each 3-digit census occupation code and then matched to the corresponding BLS occupation in their forecasts. New jobs were derived from moderate trend forecasts from the BLS. Replacement jobs were estimated by applying annual replacement rates to the average projectead employment level for the 1982-85 period for each individual occupation. Replacement rates for major occupation groups were used where no occupation-specific rates were available.

SOURCES: George T. Silvestri, John M. Lukasiewicz, and Marcus E. Einstiein, "Occupational Employment Projections through 1995," Monthly Labor Review Vol. 108 (November 1983), pp. 37-49; Alan Eck, "New Occupational Separation Data Improve Estimates of Job Replacement Needs," Monthly Labor Review, Vol. 107 (March 1984), pp. 3-10; calculations from the 1/1000 Public Use Sample, 1980 Dicennial Census.